Met Office

NEWS

Urban heat forecasts could be enhanced with machine learning

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A new study led by the Met Office highlights potential improvements to hyper-local forecasts for heatwaves in urban areas by harnessing citizen observations, land cover data and machine learning.

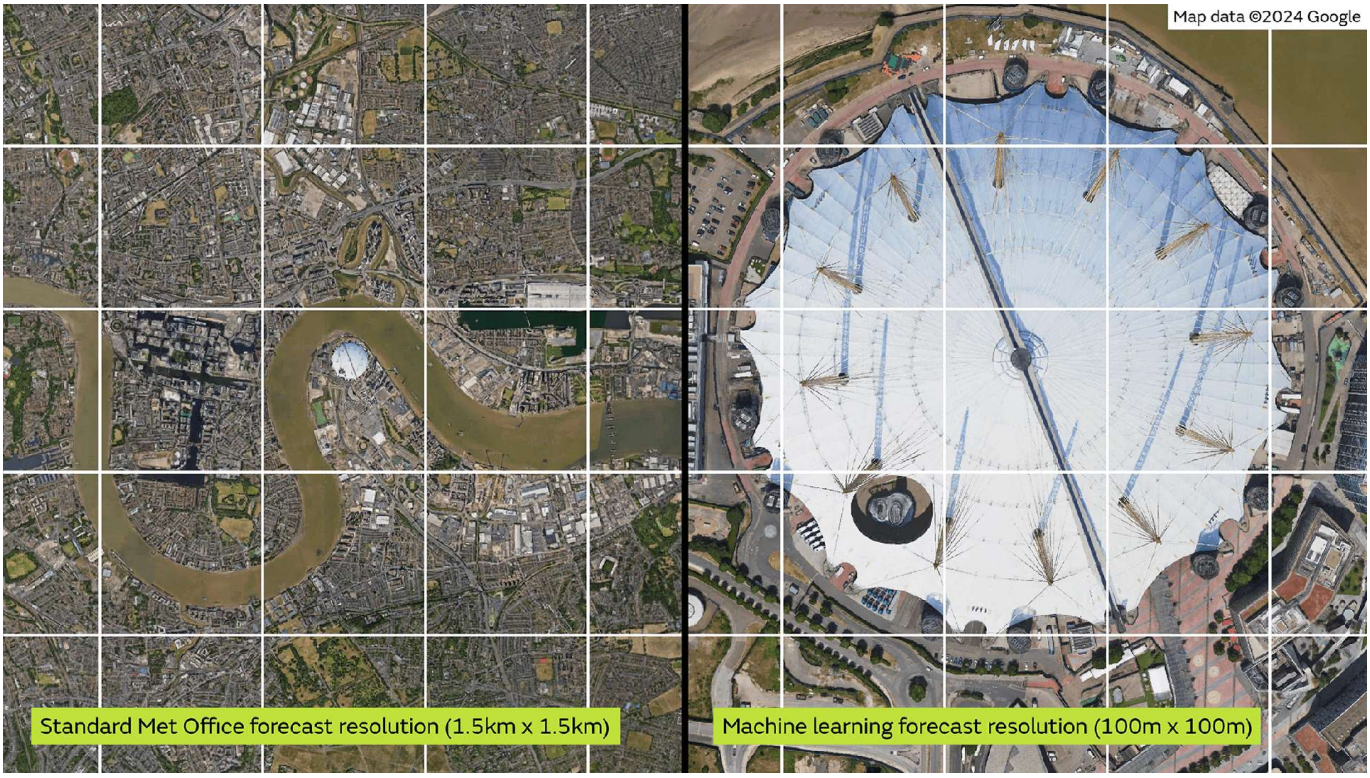
The paper, published in the Royal Met Society's Meteorological Applications Journal, is thought to be the first of its kind studying the use of citizen observations and machine learning to enhance the accuracy of temperature forecasts at a hyper-local level.

Supported by the University of Reading and the Australian Bureau of Meteorology, the proof-of-concept study looked at eight heat events London experienced from 2019-2021 and fused together operational Met Office weather forecasts with quality-controlled citizen observations and land-use data to train a machine learning model, before then testing the 'trained' system on heatwaves within the period.

The study found that machine learning methods of forecasting urban heatwaves improved prediction of air temperatures by up to 11% compared to the original weather forecast data.

In addition, machine learning allowed for temperature forecasts to be made at 225x the resolution of standard operational Met Office forecasts. Forecasting the weather using physics-based models means dividing the atmosphere over the UK into equal-sized boxes to allow weather predictions to be made for each square.

The Met Office's standard national-scale forecast has a resolution of 1.5km, which means that the grid squares are 1.5km x 1.5km. The urban temperature forecasts produced as part of this study took the resolution to just 100m, showing the potential for hyper-local forecasts for temperature, even within the same street.


Map data ©2024 Google
Standard Met Office forecast resolution (1.5km x 1.5km)
Machine learning forecast resolution (100m x 100m)

This method, combined with citizen observations and urban land cover data to aid the machine learning, allows the temperature forecast to learn from previous events and account for natural and man-made influences on the temperature, which can vary significantly within relatively short distances in cities.

Lead author and Met Office urban modelling expert Lewis Blunn said: “We can already observe an increase in extreme heat events in the UK and the greatest impacts are often felt in cities. In a warming world, machine learning can be used to better understand impacts on communities at a much finer scale and could increase resilience and ultimately save lives.

“The prediction of urban heat at hyper-local scale has often been tricky for operational weather forecast models due to the complexity of urban areas. By combining quality-controlled citizen observations and land cover data with forecast models and machine learning, this paper demonstrates the potential for enhanced temperature forecasts in urban areas at a much higher resolution.

“Being able to accurately predict heat in cities could help better inform decision-makers on where to direct resources during heatwaves, enabling improved protection of human health and infrastructure. Using machine learning to get the resolution to a 100m level would also improve the efficiency of creating highly detailed forecasts, allowing forecasts to be made more quickly and with less energy consumption.”

The study used the Met Office’s operational UK Variable forecast model output, combined with quality-controlled observations sourced from the Weather Observations Network as well as land cover information from ESA World Cover, during heat events for London from 2019 to 2021, to train the machine learning models. These models would then forecast the temperatures for other heat events within the period.

Reading PhD students Flynn Ames, Hannah Croad, Adam Gainford, Ieuan Higgs and Brian Lo played a key role in the research, helping to develop the machine learning techniques.

Hannah Croad, one of the team of PhD researchers working on the project, said: “This has been a fantastic opportunity to collaborate with the Met Office and other PhD students, while learning about machine learning and its application to weather forecasting.

“As a team, we all contributed to building the code, which meant we developed a good understanding of each step of the process. It is exciting to think that our work may provide the blueprint for new forecasting systems in the

future."

Another team member, Flynn Ames, said: "The use of machine learning in weather and climate science is growing at tremendous pace, and our work further highlights its wide-reaching applicability. We look forward to using our newly-gained skills in upcoming projects to explore further applications of machine learning within weather forecasting."

The study looked at three different possible machine learning algorithms with further detail explored as part of the peer-reviewed paper. If citizen observations across the UK and during all weather conditions were incorporated, the machine learning technique could be extended to make hyper-local predictions year-round in UK cities. It's also hoped the study will provide a base for further research into the applications of machine learning in meteorology.

The authors also demonstrated that as the number of citizen observations and heatwaves used to train the machine learning models was increased, the better the machine learning predictions became. It is therefore believed that the method will become more powerful in the future, since the number of citizens sharing their weather observation data is increasing and the time length of their records will keep growing.

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